

CLAIMS

1. An integrated device for sensing external magnetic fields comprising:  
planar magnetic field sensing means having at least a first magnetic field  
sensing element, a second magnetic field sensing element, and an  
output terminating region;  
a conductor carrying a bias current for providing a bias field for setting a  
direction of magnetization in said first magnetic field sensing element  
and in said second magnetic field sensing element in a first direction with  
said bias field being sufficient to initially align magnetization in said first  
magnetic field sensing element and said second magnetic field sensing  
element; and,  
said device having a level of sensitivity to magnetic field components in a  
direction perpendicular to said first direction and providing an output at  
said output terminating region with said level of sensitivity being related  
to a level of said bias current.

2. The device of claim 1 wherein said planar magnetic field sensing means  
comprises four magnetoresistive elements forming four legs of a Wheatstone bridge  
with opposite legs of said Wheatstone bridge having current flow in the same direction.

3. The device of claim 1 wherein said magnetic field sensing elements comprise  
elongated strips having a pattern of metal overlaid on said strips to alter the direction of  
current flow through said strips.

4. The device of claim 1 wherein said conductor carrying a bias current is in the  
form of a coil comprising at least one turn.

5. The device of claim 1 further comprising a second conductor for carrying a  
current to be measured wherein said second current creates a magnetic field  
perpendicular to said bias field and said output is an indication of a level of said current  
to be measured.

6. The device of claim 1 further comprising;  
a second device of claim 1;  
<sup>84</sup> means for supporting said device of claim 1 on a first side of a conductor  
carrying a current to be measured and for supporting said second device  
on an opposite side of said conductor, with said device of claim 1 and  
said second device lying in a common plane;  
<sup>74</sup> means for determining a combination of an output of said device of claim 1 and  
an output of said second device with said combination representing said  
current to be measured.

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7. The device of claim 6 further comprising means for varying a level of said bias  
current.

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8. The device of claim 7 wherein said output of said device of claim 1 and said  
output of said second device are connected to provide an output representing a  
difference between said output of said device of claim 1 and said output of said second  
device.

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9. The device of claim 7 wherein said means for supporting said device of claim 1  
on a first side of a conductor carrying a current to be measured and for supporting said  
second device on an opposite side of said conductor comprises a housing having a first  
leg supporting said device of claim 1 and a second leg supporting said second device.

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10. The device of claim 9 further comprising a nonmagnetic deformable resilient  
material for maintaining said device of claim 1 and said second device equally spaced  
from said conductor carrying a current to be measured.

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11. The device of claim 10 wherein said material is located between said first leg  
and said second leg and offers sufficient resistance to deformation to keep said device of  
claim 1 and said second device equally spaced from said conductor carrying a current to  
be measured.

12. An integrated device for sensing external magnetic fields comprising:  
magnetic field sensing means having first, second, third, and fourth  
magnetoresistive elements and an output terminating region, each of said  
magnetoresistive elements having first and second terminating regions,  
said first magnetoresistive element first terminating region being  
connected to said third magnetoresistive element first terminating region,  
said first magnetoresistive second terminating region being connected to  
said second magnetoresistive element second terminating region, said  
third magnetoresistive element second terminating region being  
connected to said fourth magnetoresistive element second terminating  
region and said second magnetoresistive element first terminating region  
connected to said fourth magnetoresistive element first terminating  
region;

an integral coil carrying a bias current, said current providing a magnetic field in  
a first direction and establishing an initial direction of magnetization in  
said first, second, third and fourth magnetoresistive elements in said first  
direction, and;

said device having a level of sensitivity to magnetic field components in a  
direction perpendicular to said first direction and providing an output at  
said output terminating region with said level of sensitivity being related  
to a level of said bias current.

13. The device of claim 12 wherein said magnetoresistive elements have a  
herringbone shape.

14. The device of claim 12 wherein said magnetoresistive elements comprise barber  
pole biasing.

15. The device of claim 12 further comprising;  
a second device of claim 12;  
means for supporting said device of claim 12 on a first side of a conductor  
carrying a current to be measured and for supporting said second device

on an opposite side of said conductor, with said device of claim 12 and  
said second device lying in a common plane;  
means for determining a combination of an output of said device of claim 12 and  
an output of said second device with said combination being  
representative of said current to be measured.

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16. The device of claim 15 wherein said planar magnetic field sensing means  
comprises four meander type magnetoresistive elements forming four legs of a  
Wheatstone bridge with opposite legs of said Wheatstone bridge having current flow in  
10 the same direction.

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17. The device of claim 15 wherein said magnetic field sensing elements comprise  
elongated strips having a pattern of metal overlaid on said strips to alter the direction of  
current flow through said strips.

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18. The device of claim 15 wherein said output of said device of claim 12 and said  
output of said second device are connected to provide an output representing a  
difference between said output of said device of claim 12 and said output of said second  
device.

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19. The device of claim 15 wherein said means for determining a combination of an  
output of said device of claim 12 and an output of said second device comprises  
processor means.

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20. Apparatus for measuring current within a conductor comprising:  
a first planar magnetic field sensor having magnetoresistive sensing elements, an  
integral conductor carrying a bias current and an output terminating  
region, said bias current initially aligning magnetization of said  
magnetoresistive elements in a first direction;  
30 a second planar magnetic field sensor having magnetoresistive sensing elements,  
an integral conductor carrying a bias current, and an output terminating  
region, said bias current initially aligning magnetization of said  
magnetoresistive elements in a first direction;

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a housing positioning said first magnetic field sensor on a first side of said conductor and positioning said second magnetic field sensor on an opposite side of said conductor with said first planar sensor and said second planar sensor lying in a common plane perpendicular to said conductor;

5 means for determining a combination of an output of said first magnetic field sensor and an output of said second magnetic field sensor with said combination being representative of said current to be measured.

10 21. Apparatus of claim 20 wherein said first magnetic field sensor and said second magnetic field sensor comprise four meander type magnetoresistive elements forming four legs of a Wheatstone bridge with opposite legs of said Wheatstone bridge having current flow in the same direction.

15 22. Apparatus of claim 20 wherein said first magnetic field sensor and said second magnetic field sensor are connected so as to provide an output representative of a difference between an output of said first magnetic field sensor and an output of said second magnetic field sensor.

20 23. Apparatus of claim 20 further comprising means for varying said bias current in said first magnetic field sensor and said second magnetic field sensor.

24. Apparatus of claim 20 wherein said housing comprises a first leg and a second leg extending on opposite sides of said conductor.

25 25. Apparatus of claim 24 further comprising a non-magnetic deformable resilient material located between said first leg and said second leg.

30 26. Apparatus for measuring current within a conductor comprising:  
a first magnetic field sensor;  
a second magnetic field sensor  
a housing positioning said first magnetic field sensor on a first side of said conductor and positioning said second magnetic field sensor on an

opposite side of said conductor with said first sensor and said second sensor lying in a common plane;

means for determining a combination of an output of said first magnetic field sensor and an output of said second magnetic field sensor with said combination being representative of said current to be measured.

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27. Apparatus of claim 26 wherein said first magnetic field sensor and said second magnetic field sensor are Hall type elements.

10 28. Apparatus of claim 26 wherein said first magnetic field sensor and said second magnetic field sensor comprise magnetoresistive elements.

15 29. A method of measuring a current in a conductor comprising the following steps: providing a first planar magnetoresistive magnetic field sensor having an integral coil for providing a bias field;

providing a second planar magnetoresistive magnetic field sensor having an integral coil for providing a bias field;

positioning said first magnetic field sensor on a first side of said conductor and said second magnetic field sensor on an opposite side of said conductor;

20 applying a current to said integral coils;

determining an output of said first magnetic field sensor and said second magnetic field sensor; and

calculating a current in said conductor.

25 30. The method of claim 29 wherein the step of positioning comprises the step of placing the magnetic field sensors in a common plane perpendicular to said conductor.

31. The method of claim 29 wherein the step of calculating a current in said conductor includes the step of providing a microprocessor for calculating.

30 32. The method of claim 29 wherein the step of applying a current to said integral coils includes the step of duty cycling said current to said integral coils.

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